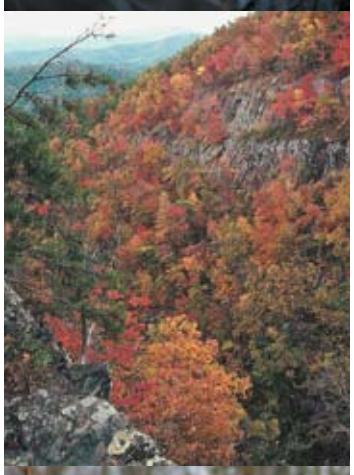


Chapter 3:

The Importance of Forests as Habitat

Key Findings

- The Chesapeake Bay watershed has some of the most biologically diverse forests in the nation.
- Forests are more homogenous in age, size, and composition than at any other time over the past several thousand years, resulting in major shifts in forest habitats.
- More than 99% of the pre-settlement eastern deciduous old-growth forest ecosystem is gone.
- Forest loss and fragmentation have left only 40% of Chesapeake forests capable of producing enough habitat to support healthy populations of interior forest-dwelling species.
- Oaks are the most voluminous and ecologically important trees in today's Chesapeake forests, but in many places, the number of oak seedlings and saplings are insufficient to replace the existing forest.
- Red maple is becoming the most dominant species in Chesapeake forests, replacing tree species with greater habitat value.
- Deer populations are out of balance, making deer a key factor impacting forest health and sustainability.
- Invasive forest pests and plants have permanently altered the native biodiversity of Chesapeake forests and the habitats they provide. The continued introduction of new pests is a serious concern that could have significant consequences.
- Over 6 million acres or 45% of the Bay watershed's network of forests and wetlands is vulnerable to development.

The Composition of Chesapeake Forests

The combination of a warm and moist climate, mountainous topography near coastal plains, deep soils, and confluence of northern and southern species has allowed the forests of the Chesapeake Bay watershed to become one of the most diverse temperate forests in the United States.[1] Chesapeake forests contain a rich mix of ferns, groundcover plants, shrubs, and trees.[2,3]

Shifts in Forest Type

Currently, four types of forestland make-up 92% of all Chesapeake forests. Each type is dominated by a different set of tree species:

- Oak/hickory
- Oak/pine
- Maple/beech/birch
- Loblolly/shortleaf pine

The remaining 8% of the forest consists of nine additional forest types, including white/red/jack pine and oak/gum/cypress, which occur along the edges of the Chesapeake Bay watershed and its waterways.

Forest types are associated with unique plant and animal communities. For example, oak/hickory forests are dominated by oak and hickory trees, but include many other species reflective of local conditions including red maple, flowering dogwood, mountain laurel, blueberry, mayapple, and jack-in-the-pulpit. Associated animals include the blue jay, wild turkey, eastern gray squirrel, eastern chipmunk, and spotted salamander. Forest types change because of human disturbance (such as fire suppression, planting and harvesting, development, and grazing) or because of natural succession. Changes in climate affects the range of different forest types.

Half of all forest types in the Bay watershed lost area between the mid-1980s and early 21st century. The plants and animals associated with these forest types were likewise affected. The area of maple/beech/birch increased 20%, while oak/pine and loblolly/shortleaf pine each lost approximately 10%. Oak/hickory acreage remained essentially unchanged.[4] Other forest types gained enough area to minimize total forest loss, but the decrease of individual forest types reduces overall biodiversity. This is because different plants and animals live in different types of forests.

Change in Tree Species

Oaks are the most important trees in Chesapeake forests to wildlife and provide numerous other benefits such as soil stabilization and high timber value. White and red oaks are the most abundant species in the Bay watershed in terms of volume, with over 13 billion cubic feet.[5] Before European settlement, large oak populations were fostered by frequent low-intensity fires that were either set deliberately by Native Americans or resulted from natural sources. Oak survives fire better than other trees, like red maple, because of its thick insulating bark and prodigious ability to re-sprout from dormant buds that occur at or below the soil surface.[6]

In many parts of the Bay watershed, the prominence of oak in future Chesapeake forests is uncertain.[7] Oak is in decline across the Bay watershed because of unsustainable timber harvesing practices, fire suppression, repeated gypsy moth infestations, and over-browsing by deer.[8] A study in West Virginia has shown that there has not been enough regeneration to sustain most major oak species over the last 50 years.[7] While history suggests that approximately 3,600 seedlings per acre would be needed to replace an existing stand of northern red oak, current oak seedling densities seldom exceed 970 seedlings per acre—primarily due to deer browsing.[8] Preliminary studies show similar deficiencies in hickory seedling densities as well.[9] In all regions of the Bay watershed, oak volume has declined in the past 20 years.[6] Studies show similar trends in all states in the region. For example:

- Oak trees in Virginia declined from 34% of all trees in 1966 to 18% in 2001.[6,10]
- The total tree volume of Maryland's oak species declined from 45% in 1950 to 28% in 1999.[11]

Major Forest Types in the Chesapeake Bay Watershed

Forest Type	Area in Acres (thousands)	Percent of Forestland	Change 1987-2001	Dominant Species	Associated Species
Oak Hickory	11,964	52.4%	-0.3%	White oak, Red oak, Chestnut oak, other Upland oak and Hickory	Yellow poplar, Sweetgum, Red maple, Mountain laurel, Blueberry, Mayapple
Maple Beech Birch	5,268	23.1%	19.5%	Sugar maple, Beech or Yellow birch	Cherry, Red maple, Ash, Elm, Basswood, Eastern hemlock, White pine, Viburnum, Witch hazel
Loblolly Shortleaf pine	2,000	8.8%	-7.4%	Loblolly pine, Virginia pine	Pitch pine, Oak, Hickory, Black gum, Sweetgum
Oak Pine	1,696	7.4%	-10.5%	Red oak, Hickory, White ash, Loblolly pine, or Virginia pine	Black gum, Sweetgum, Sourwood, Yellow-poplar, Striped wintergreen, Maple leaved arrowwood
White, Red & Jack pine	657	2.9%	-20.4%	Eastern white pine, Red pine or Jack pine	Eastern hemlock, Aspen, Birch, Maple, Blueberry,
Elm Ash Cottonwood	428	1.9%	-13.0%	Elm, Ash or Cottonwood	Willow, Sycamore, Birch, Maple, Hackberry, Poison ivy, Blueberry
Oak Gum Cypress	309	1.4%	4.4%	Sweetgum, Nuttall oak, Willow oak, Sweet bay magnolia, Black gum, Swamp tupelo, Red maple, Cypress	Cottonwood, Willow, Ash, Elm, Hackberry

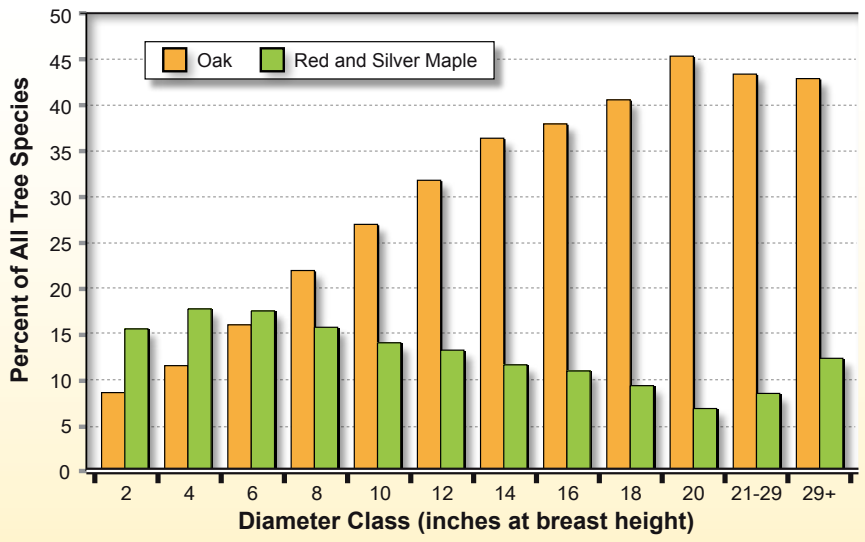
Source: USDA Forest Service / FIA 2005

Perhaps most alarming, young oak seedlings are under represented throughout Chesapeake forests, indicating that the trees will have a lower presence in the region's future forests.[6]

Red maple has greatly expanded its range over the past 100 years. While red maple is by far the most abundant tree in the Bay watershed today, it was not included in a list of more than 600 kinds of trees and other plants by naturalists in colonial Maryland.[20] Today, red maple comprises 90% of forest regeneration in Pennsylvania and has been the most widespread species in the state for the past 25 years.[21,22] The success of red maple is unnatural, however, because of its resistance to diseases that commonly affect competing species, fire exclusion, the selective harvesting of more prized timber, and the tree's ability to survive in a wide variety of soils and climate.

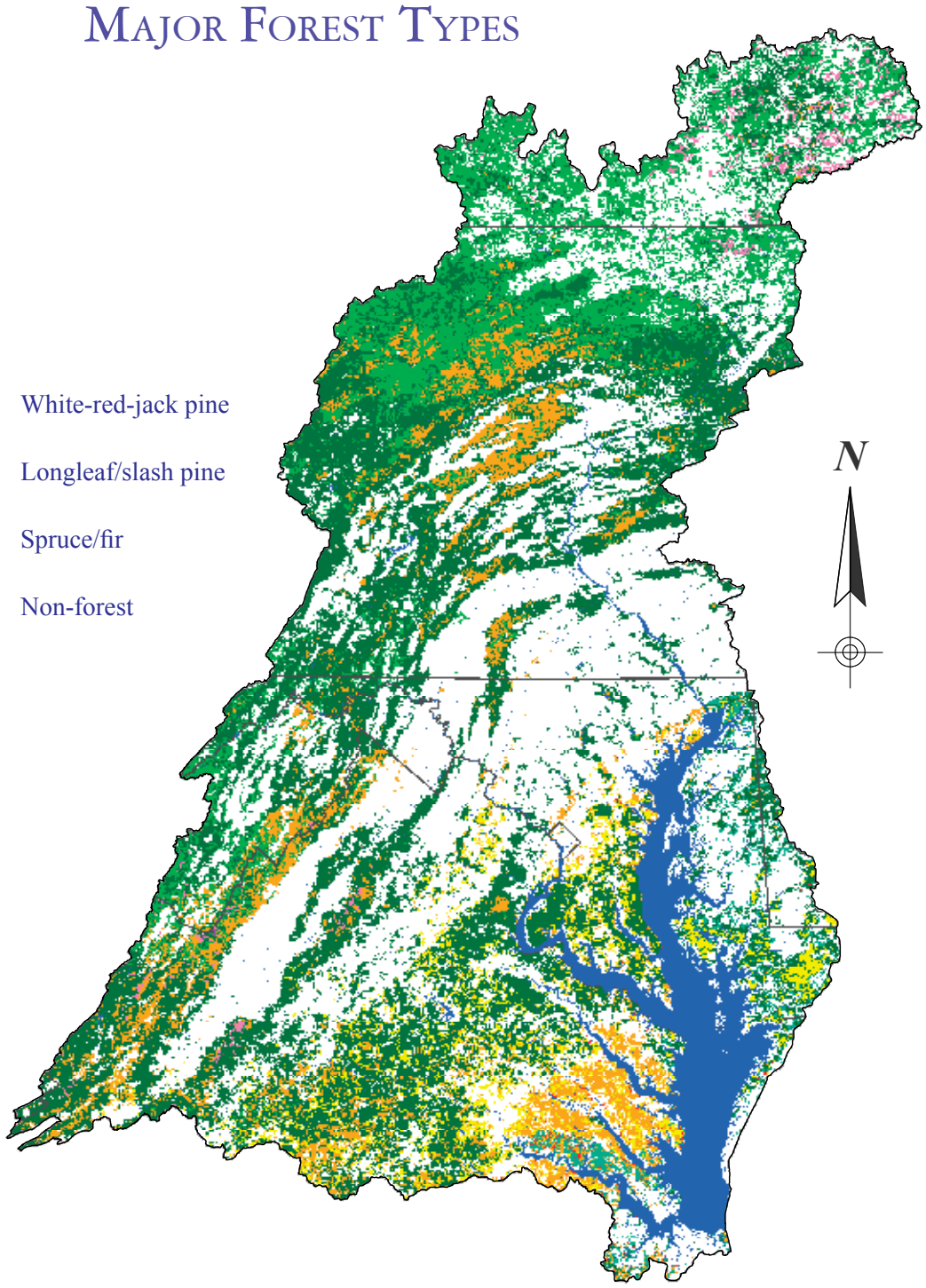
With more than 2 billion trees, red maple is almost three times as numerous as the next most common species, black gum. Maples are the second most abundant species group in terms of volume, with more than 7 billion cubic feet.[6] However, if oak regeneration continues to fail and young maples grow larger, maple will likely assume prominence as the most voluminous tree in the watershed.

Size Distribution of Oak and Maple Species



Source: USDA Forest Service / FIA 2005

Major Forest Types



INTERPRETATION:
The Oak/Hickory (52%) and Maple/Beech/Birch (23%) forest types dominate the area of forest cover. Eleven other forest types make up the remaining 25%. Longleaf/Slash pine and Spruce/fir are localized in southern Virginia and high-elevation areas respectively.

SOURCE: National Atlas 2005

Harvest Choices Effect Forest Type

By high grading their forests, landowners may unknowingly degrade forest conditions for several decades or more, reducing the long-term economic and ecological value of their land. A hypothetical oak/hickory forest located in central Pennsylvania was used to model the impacts using a "diameter limit cut"—a common form of high grading that removes trees over a certain diameter.[23]

Before harvesting in 2003, the model forest is dominated by red maple, hickory, and red oak, but also includes dogwood, striped maple, chestnut oak, and white ash. All trees on the property more than 15 inches in diameter are then harvested to maximize profits. This initial harvest removes most of the red oak and red maple, and smaller amounts of hickory and striped maple. As is common, the landowner conducts three more harvests over the next 50 years, removing trees greater than 13, 11, and 9 inches in diameter respectively. By 2053, the original forest has drastically changed. The forest canopy is composed of a few remaining hickory, with dogwood in the forest midlayer. Chestnut oak and white ash have been completely removed and striped maple, red oak, and hickory are greatly reduced.

On the other hand, young red maple and sweet birch have thrived in the conditions provided by the removal of the larger trees. Red maple—released by the large tree harvest in the first year—becomes the most numerous species in the stand, followed closely by sweet birch. Sweet birch, not present in the original forest, colonizes the forest and prevents slower growing species like oak from establishing in forest gaps. Of these two species, 99% of the trees are less than three inches in diameter. In the end, the forest stand is much more dense and slow-growing than the original stand, with more than 1,100 additional trees per acre and 16% more canopy cover.

As gaps are created by the loss of the few remaining hickory trees, the stand will eventually be a red maple/sweet birch forest with significantly less economic and ecological value than the original oak/hickory forest that existed before the high grading took place.

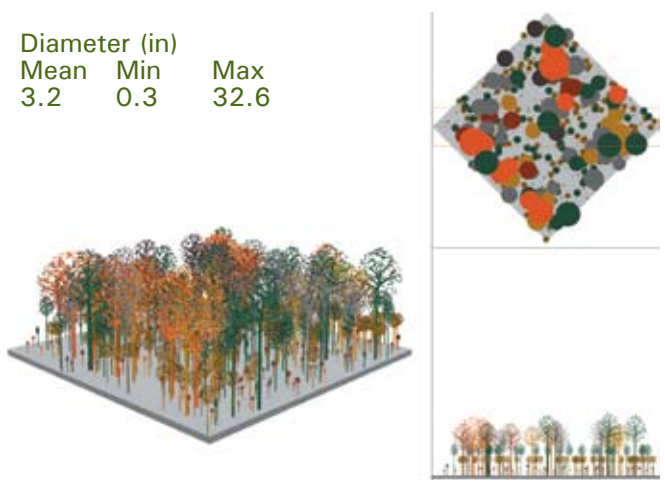
State and private foresters can provide guidance and help create management plans to ensure economic and ecological sustainability.

Forest Conditions Before First Harvest, 2003

Tree	Tree color	Trees/Acre
Red Maple	Red	181
Hickory	Dark Green	159
Red Oak	Orange	111
Dogwood	Brown	55
Striped Maple	Gray	35
Chestnut Oak	Gold	12
White ash	Black	6
Sweet birch	Light green	0
TOTAL		**561**

Diameter (in)

Mean	Min	Max
3.2	0.3	32.6

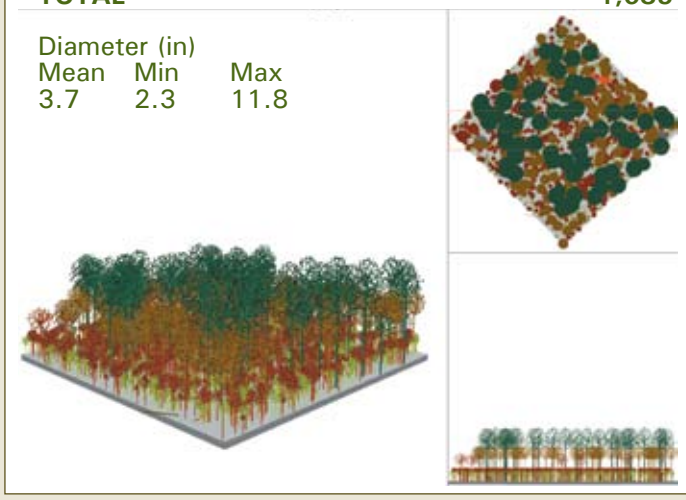


Forest Conditions 50 Years After Initial Harvest, 2053

Tree	Tree color	Trees/Acre
Red Maple	Red	754
Hickory	Dark Green	144
Red Oak	Orange	67
Dogwood	Brown	3
Striped Maple	Gray	3
Chestnut Oak	Gold	0
White ash	Black	0
Sweet birch	Light green	715
TOTAL		**1,685**

Diameter (in)

Mean	Min	Max
3.7	2.3	11.8



This analysis was created using stand visualization software (SVS). SVS allows landowners to collect data and create images of their forests and visualize how their forests will change in response to management action and natural events.

Rare and Unique Forest Habitats

Longleaf Pine

In the southeastern United States, 98% of pre-settlement longleaf pine forests were lost by 1986. Longleaf pine was never widespread in the Chesapeake region, since the species reaches its most northerly range only in the southernmost portion of the Bay watershed. However, remnants of longleaf pine forests still exist and are important to the region's biodiversity. Longleaf pine depends on wildfires to regenerate and is at risk in most of its range due to fire suppression.

Atlantic White Cedar

Approximately 98% of Atlantic white cedar stands have been lost. This forested wetland species can be found in peat bogs with numerous rare plants, and animal assemblages, especially insects. Atlantic white cedar is restricted to a narrow belt (30 to 120 miles) along the Atlantic Coast. Most stands in the Chesapeake region are on the Eastern Shore of Maryland. The few stands west of the Bay are genetically distinct and represent the western extent of the species in the mid-Atlantic.

Forested Wetlands

Wetlands overall have declined by almost 60%, translating into a loss of more than four million acres in the Bay watershed since 1780. New York and Maryland account for nearly two thirds of the total decline in wetlands in this region. Maryland has lost almost 75% of its wetlands since the last years of the American Revolution.[24]

Between 1982 and 1989, the National Wetlands Inventory (NWI) indicated that approximately 14,700 acres of forested wetlands were converted to other land uses—the greatest loss for any wetland type. Nearly 75% of these losses were in Virginia. Other hot spots occurred on Maryland's Eastern Shore, in western Delaware, and in northeastern Pennsylvania.[25] Timber harvests in forested wetlands, especially loblolly pine systems, do not result in a loss of wetlands, but rather represent a shift in the age and species structure, with effects on habitat and hydrology that are most often only temporary.

Forested wetlands now only make up 2% of all natural vegetation and are common in areas of the Bay watershed that have saturated soils.[26] In the Coastal Plain, forested wetlands are found in both freshwater tidal and non-tidal floodplains of rivers and streams and in upland areas with poor drainage. This unique habitat includes wetland species such as tupelo, baldcypress, and swamp oak. Within the Coastal Plain on the Delmarva Peninsula, patches of wet forestland over flat terrain are supported by seasonally high water tables that persist from late winter through late spring. Much of the historic wetland forests in areas such as the Delmarva have been drained and cleared for use as farmland. For example, an extensive network of maintained ditches on the Eastern Shore of Maryland and Virginia keeps once-forested wetlands

Clockwise from top left: Longleaf Pine Woodland, Atlantic White Cedar Forest (dark, coned-shaped tree crowns), Forested Wetland, and Red Spruce forest.

Photos by: Gary P. Fleming and Caren Caljouw © VA DCR Natural Heritage

The Role of Nut-Bearing Trees

Nut bearing trees such as oak, American chestnut, American beech, and hickory depend on songbirds, small mammals, and even bears to disperse their seeds. A study on blue jays in Virginia noted that 50 birds transported 150,000 acorns in one month.[12] Animals are amazingly capable of retrieving most of their store of acorns, but, in large nut production years, they may not need their entire cache and unretreived acorns can add significantly to regeneration.

The relationship between nut bearing trees and animals is not one-sided, however. Nuts are a critical source of high-energy food.[13] The populations of small mammals, such as the white-footed mouse, rise and fall because of good and poor acorn production years. Numbers of hawks and owls, whose principal prey is small mammals, are in turn affected.[14] Black bear distributions also fluctuate with the availability of nuts. Acorns are the preferred food of bears and can be their only source of energy during winter.[15]

Large, nut-producing trees have been declining over the past 100 years. When the American chestnut was essentially eliminated from Chesapeake forests in the mid-20th century, wildlife lost a valuable food source. Chestnut trees with a diameter of 14 to 16 inches produced 300 to 900 nuts per tree, and larger trees could produce as many as 6,000 nuts.[16] Other nut-bearing trees such as hickory, chestnut oak, northern red oak, and white oak have gradually replaced American chestnut in portions of Chesapeake forests. While some oak species can produce more nuts than the American chestnut, they have less nutritional value and produce acorns less frequently. Thus, oak trees have not been able to fully replace the wildlife value of the chestnut.[17]

Oak, particularly white and northern red oak, is now the greatest acorn producer in Chesapeake forests. Forty-nine species of birds and mammals use oak nuts and foliage in the eastern United States. However, this important food source is in decline. Poor timber harvesting methods, gypsy moth infestations, and regeneration failure have contributed to the decline of oak throughout the Bay watershed.[18]

In contrast to the decline of oak, red maple is steadily increasing. While many wildlife species rely on acorns, very few use red maple seeds as a food source. Red maples are also used less by Neotropical migratory birds for sources of caterpillars. In addition, the smooth bark of maple provides less surface area and crevices for small insects to "hide" than the rough-barked oaks. Because of this, chickadees searching for food have been known to avoid smooth-barked trees like red maple.[19]

Photo: U.S. Forest Service

dry enough to produce crops such as soybeans. In the Piedmont, forested wetlands are typically found on broader stream valley floodplains like the Potomac, along narrower riparian areas following stream systems, and in springs and groundwater seepage areas. Forested wetlands in the Ridge and Valley and Appalachian Plateau occur along similar terrain and are found in association with headwater landscapes of various stream systems.

Red Spruce

Red spruce was once dominant in higher elevations, growing to diameters greater than five feet. Like other conifers, red spruce provides shelter for wildlife in winter and is used year-round for nesting and protection. West Virginia has lost up to 90% of its red spruce forests.[27] In the past 20 years, however, there has been no significant increase in mortality, and red spruce is starting to occur in lower elevations of the Appalachian Mountains. Still, global warming, acid rain, droughts, spruce budworm, windthrow, fire, and other forces threaten the continued presence of this tree in Chesapeake forests.

Change in Understory Species Composition

Plants form the base of the forest food web, which in the Chesapeake region includes more than 3,000 different plants and animals. Unlike in other areas, most understory plants in the mid-Atlantic are perennial. This means they are relatively long-lived with roots that may spread underground across wide areas, putting up new shoots from the same genetic individual. This act of "cloning" is common in forest species such as mayapple, trillium, pawpaw, trout lily, and many other wildflowers.

The root system and growth cycles of understory plants are especially sensitive to soil disturbance, compaction, and overbrowsing by deer. Forest harvesting practices such as clearcutting, land clearing, plowing, or recontouring the land can severely affect most of the understory plants, which may need decades to re-establish. Increased sunlight and the highly disturbed soil that follows these more intensive land use practices encourages the establishment of invasive species.

In large portions of Pennsylvania, Maryland, and Virginia, overbrowsing by white-tailed deer has essentially eliminated the tree seedling, sapling, and shrub layers, reducing

the vertical structure of forests. Pennsylvania has experienced the greatest effects with thousand of square miles of habitat damaged by deer. In a hemlock-beech forest in western Pennsylvania, deer had reduced plant species from 41 in 1928 to 21 in the mid-1990s. Areas providing sanctuary for wildflowers—many imperiled—were seen only in areas inaccessible to deer, such as the tops of boulders.

In heavily settled parts of Pennsylvania, where hunting pressure is light or nonexistent, it is not unusual to have more than 75 deer per square mile. A 10-year study by the U.S. Forest Service determined that at more than 20 deer per square mile, there is complete loss of cerulean warblers (on the Audubon WatchList as a species of global concern), yellow-billed cuckoos, indigo buntings, eastern wood pewees, and least flycatchers. At 64 deer per square mile, eastern phoebes and even robins disappear.[28] Some understory species, such as spicebush and pawpaw, are not preferred by deer and have become overabundant in the region. Native plant losses are four times greater in places that have little to no deer hunting.[29] Invasive species have also degraded the native layer of forest shrubs. The presence of these species depresses amphibian, small mammal, and bird populations and further limits forest regeneration.[30]

Photo: Will McWilliams

Vegetation flourishes on the other side of a deer fence.

Photo: Gary P. Fleming © VA DCR Natural Heritage

Large Flowered Trillium and Golden Ragwort in George Washington and Jefferson National Forests

The Oldest Living Organism in the Bay Watershed

In a forest understory near the Juniata River in Perry County, Pennsylvania, is a clone-forming stand of the box-huckleberry shrub that measures more than a mile wide. Scientists agree that this sizable box-huckleberry patch appears to have originated some 8,000 to 13,000 years ago, eclipsing by far the age of the giant sequoias and bristle-cone pines in the western United States. This Pennsylvania box-huckleberry patch is the oldest known living thing in the Chesapeake Bay watershed and is one of the oldest plants on Earth.[31]

Photo: Larry Morse © LEM National Diversity

The Changing Structure of Chesapeake Forests

The physical structure of a forest is a critical habitat element because forests are naturally extensive and multi-layered—from the roots to the canopy. Forest structure provides a multitude of micro-niches, as well as nesting sites and shelter from weather and predation. For forest interior dwelling plants, forest structure provides vertical growing space and climate control.

Loss of Interior Forest Habitat from Fragmentation

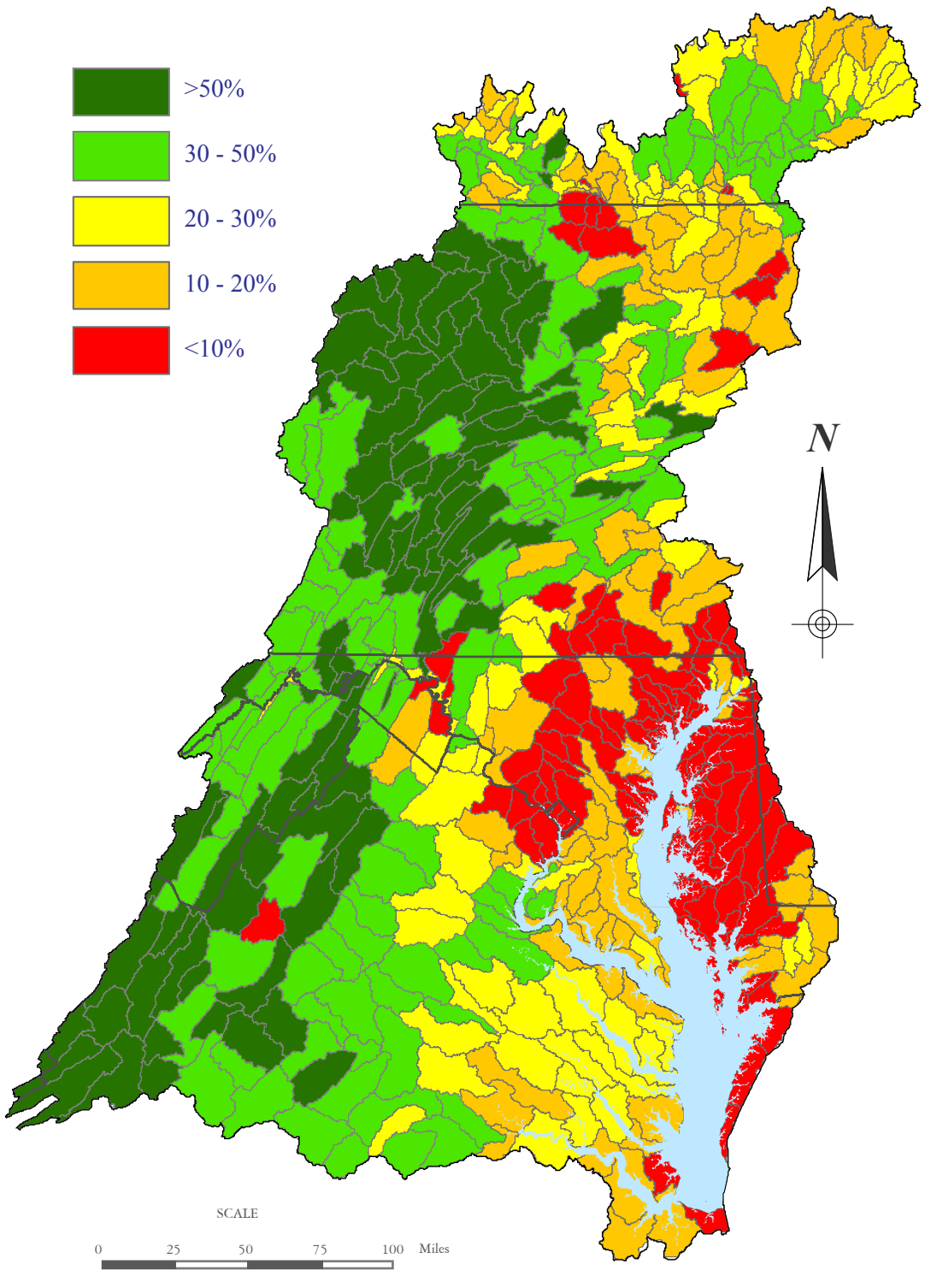
The smaller size and lack of contiguity of today's forests makes them much less functional for some species of wildlife. Farms, roads, residential developments, and other human uses fragment forests into various-sized patches. Some species require the unique characteristics of "interior" forest—forest that is relatively mature and separated from other land use or forest types. Only 40% of Chesapeake forests provide interior habitat area (300 feet from a non-forest edge) for sensitive species like the scarlet tanager.[32] Interior forest habitat not only provides shelter from weather and predation, but also moderates temperature and light levels that are especially important to plants and wildlife in the summer. In addition, forest fragmentation isolates animal and plant populations by creating gaps in forest cover that are too wide or too dangerous to cross.

Infrastructure like roads and railroads confine larger, contiguous forest patches in areas with little agriculture or development. The majority of forest patches in the Bay watershed are less than 1,000 acres—an indicator of low amounts of interior forest.[33]

INTERPRETATION: Nearly all land animal and plant species evolved in forests with interior conditions, protected from the affects of extreme weater and predation where forestland abuts non-forestland. Some species have adapted to the loss of interior forests, but many have not and are threatened by its continued loss due to forest conservation and fragmentation.

SOURCE: U.S. EPA Region 3 2005

Percent of Watershed Forest with Interior Conditions, 2000



In addition to forest area and amount of interior habitat, adjacent land use plays an important role in the habitat suitability of forest fragments. A study on breeding bird communities in central Pennsylvania found that mature forest patches surrounded by agricultural landscapes had fewer forest-associated species and a greater number of species along the forest edge than similar forests surrounded by tree harvesting.[34]

Despite the decline of interior forests, there are still extensive forests with high ecological value in the Bay watershed. The Chesapeake Bay Program has identified the remaining high quality forestland that provides ample space for breeding and migration. The highest valued areas are:

- Large and intact, with interior conditions
- Habitat for rare, threatened, or endangered species or unique natural communities
- Highly diverse
- Aquatic or riparian habitats
- Remote from human disturbance such as roads

Based on current development patterns, 45% of the Bay watershed's network of forests and wetlands is vulnerable to development.

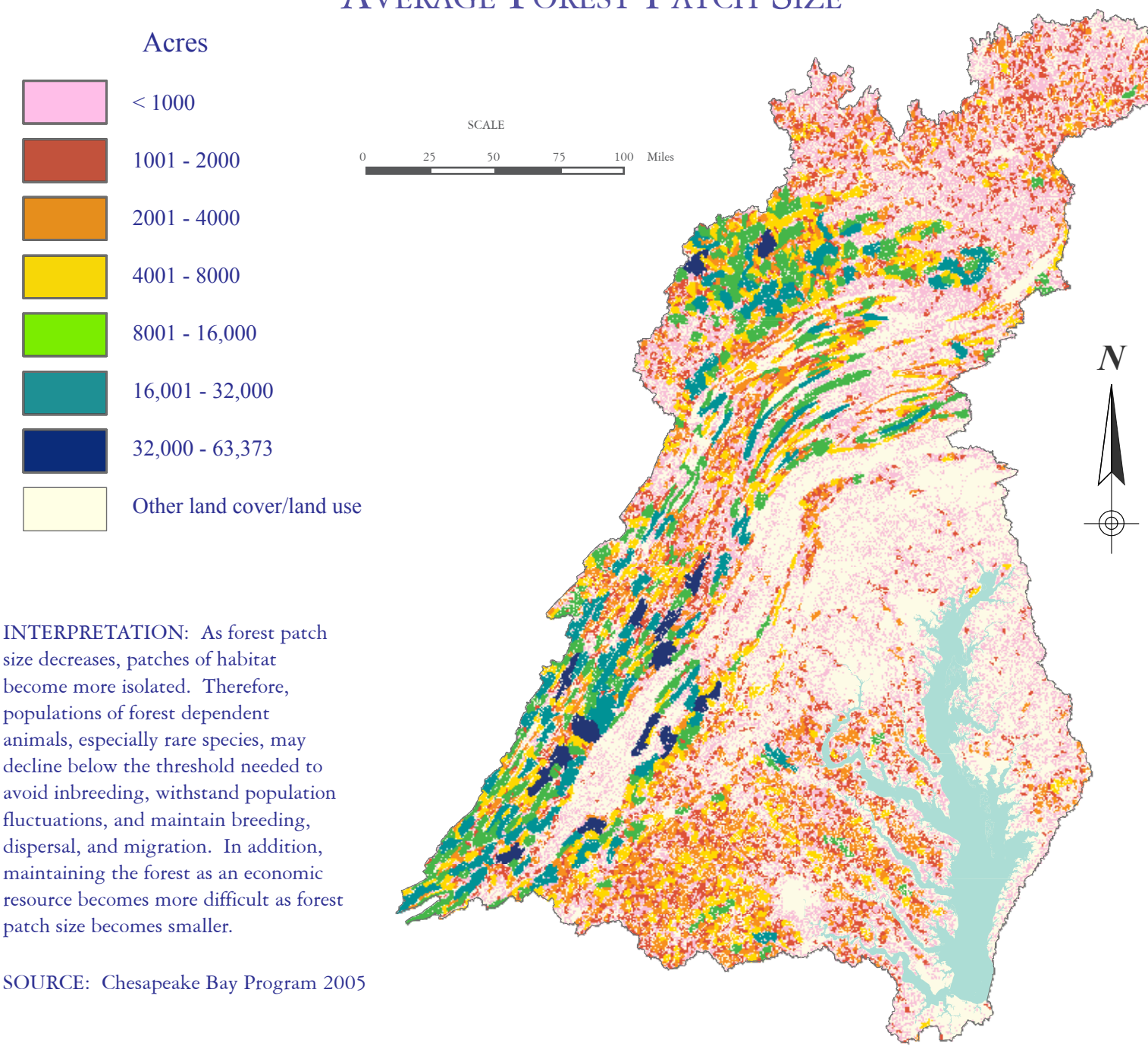
Forests of Similar Age and Size

Many Chesapeake forests we see today began growing on abandoned farmland and heavily logged forestland between 1900 and 1960. These forests are still growing and thanks to the region's highly productive soils and long growing seasons, they may be growing more quickly than forests in any other area of the country.[35,36] Forests in the 50 to 100 year age range dominate the Bay watershed, resulting in a relative scarcity of younger and older forests and the habitats they provide.[6]

The trees in Chesapeake forests are similarly sized. Almost 60% of the Bay watershed is dominated by stands of "large" trees—that is, hardwood and softwood trees at least 11 and 9 inches in diameter respectively. Over the past two decades, the volume of these growing trees has increased by 14%, with the greatest growth in trees 17 inches in diameter or larger.[6]

While larger trees continue to mature, newly

Average Forest Patch Size



INTERPRETATION: As forest patch size decreases, patches of habitat become more isolated. Therefore, populations of forest dependent animals, especially rare species, may decline below the threshold needed to avoid inbreeding, withstand population fluctuations, and maintain breeding, dispersal, and migration. In addition, maintaining the forest as an economic resource becomes more difficult as forest patch size becomes smaller.

SOURCE: Chesapeake Bay Program 2005

established seedling and sapling forests have declined. Trees below nine inches in diameter—those that most influence future forest composition—have declined by 8% over the past 20 years.[6] Forest understories are more often found barren of seedlings, when their maturity would suggest that they support new trees. In essence, the average forest age has increased not as much because there are a greater number of older trees, but because there are far fewer young ones.

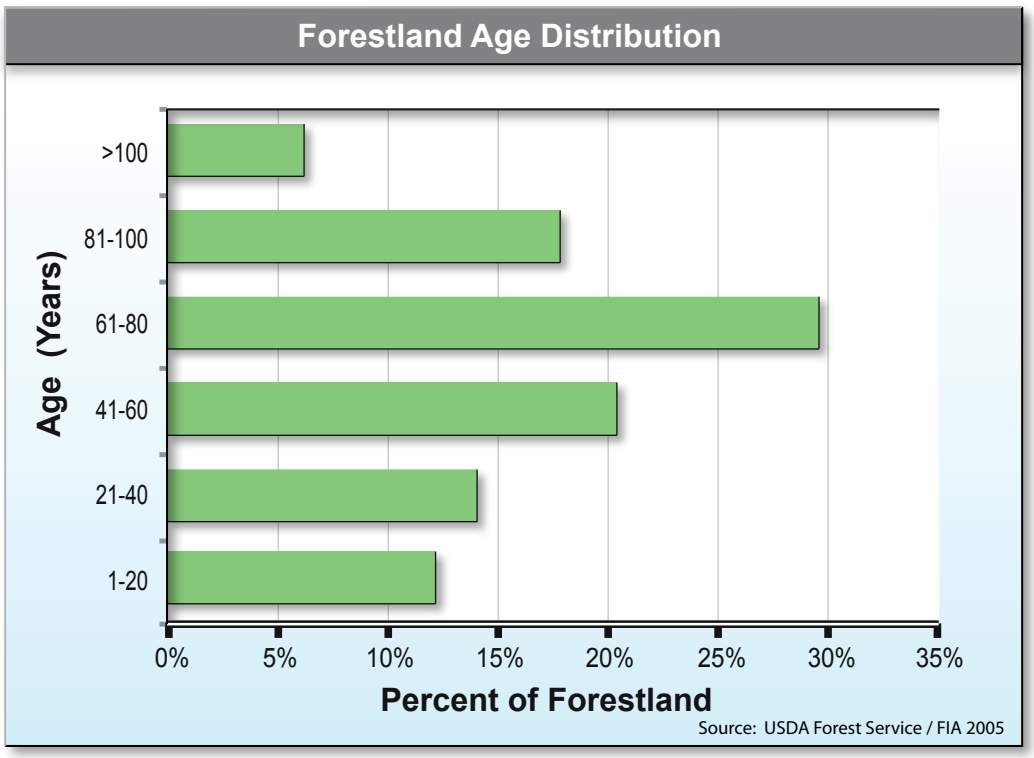
Early Successional Forests

Species dependent on early successional habitats are said to be the fastest declining group of wildlife in the northeast. While fire or browsing may have maintained some large early successional habitats in pre-European settlement forests, most occurred as small patches of trees, shrubs, and other plants that emerged as forest openings after disturbances. Currently, early successional forestland makes up about 10% of all forests in Pennsylvania, New York, and West Virginia. Historically, these headwater regions may have had less than 3% of the total early successional forest that existed 400 years ago. The coastal states of Delaware, Maryland, and Virginia currently have about 15% of their forests in early successional habitat, the same level that may have existed in pre-European settlement forests.[4,37]

As Chesapeake forests mature, many forest species like pileated woodpeckers and black bears are reclaiming past territories at the expense of early successional species. In Pennsylvania, at least four reptile, twenty bird, and three mammal species are likely to decline because of the continued loss of early successional habitat.[19]

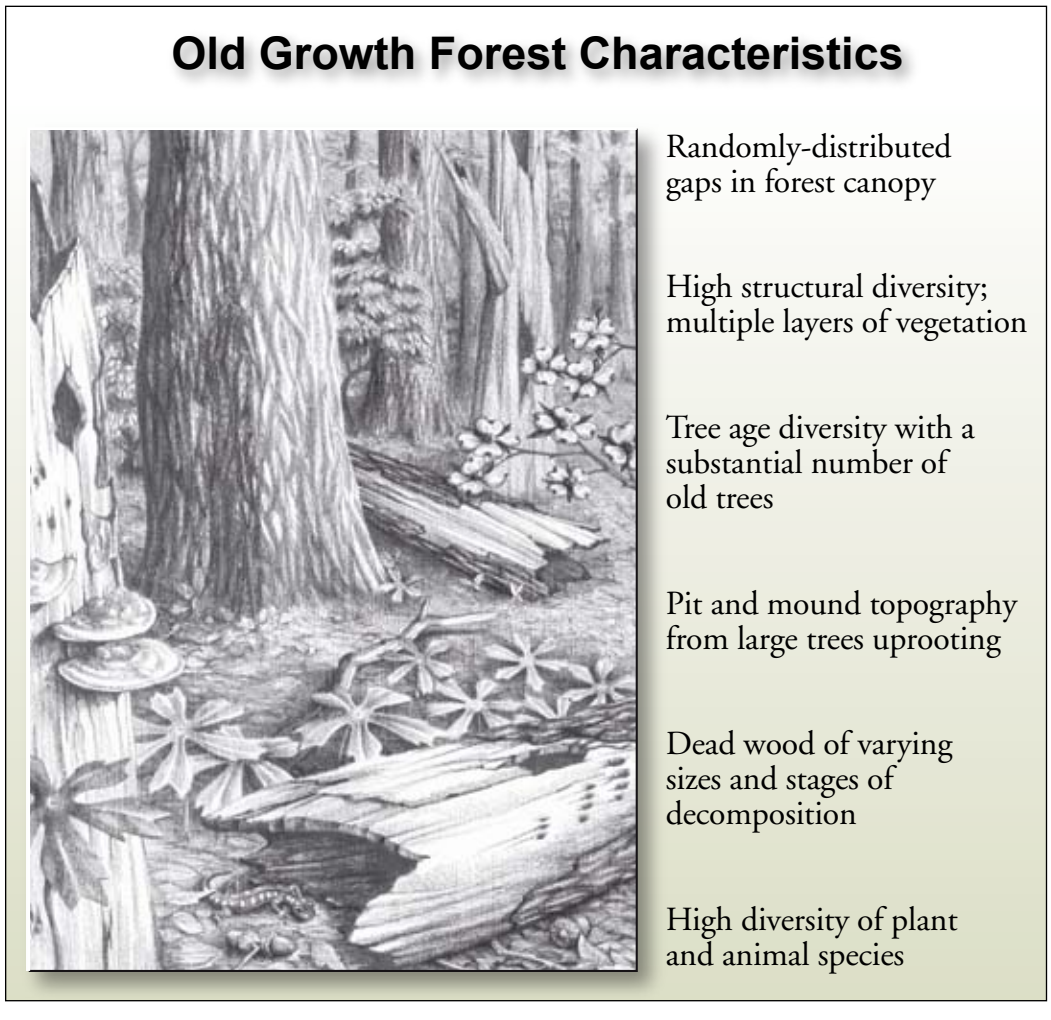
Old Growth Forests

Given the human use of Chesapeake forests over the past 400 years, old-growth forests have been largely absent from this region for a long time. Today, it is thought that more than 99% of the original eastern deciduous old-growth ecosystem has been lost.[27] Old-growth forestland in the eastern United States covers approximately 2.2 million acres or 0.6% of all forest. The Bay watershed currently has approximately 42,000 acres of old-growth forest, representing 0.2% of all forestland.[38] The remaining areas of old-growth forest survive in small patches primarily in areas that humans found difficult to access, like remote areas and steep slopes.

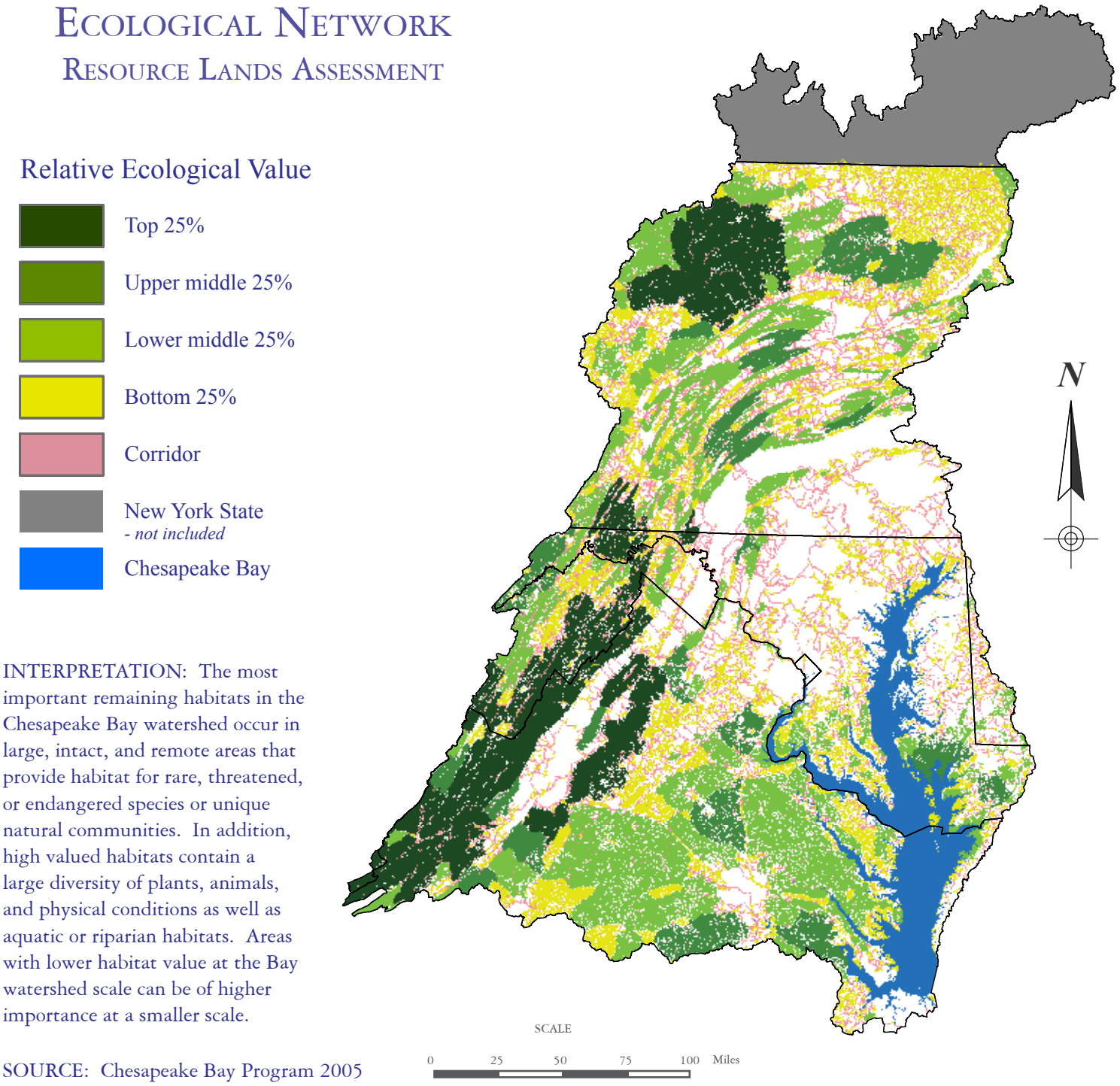


Old-growth forests were heavily degraded during the mass conversion of forestland to agriculture and timber operations in the 19th century over most of the Bay watershed. Current forests are relatively young and even-aged and cannot yet provide the full range of habitats that a more structurally diverse, old-growth forest contains.

Like all forests in the Bay watershed, old-growth forests are not static. The forests and trees within and around them change continuously. This would be true even if human influence could be eliminated. Old-growth forests succumb to natural, disturbances and then regenerate over time.



Ecological Network
Resource Lands Assessment



INTERPRETATION: The most important remaining habitats in the Chesapeake Bay watershed occur in large, intact, and remote areas that provide habitat for rare, threatened, or endangered species or unique natural communities. In addition, high valued habitats contain a large diversity of plants, animals, and physical conditions as well as aquatic or riparian habitats. Areas with lower habitat value at the Bay watershed scale can be of higher importance at a smaller scale.

SOURCE: Chesapeake Bay Program 2005

Snags and Fallen Trees

Standing dead trees (snags) and decomposing logs and stumps on the forest floor, known as coarse woody debris, are important to many ecological processes, including nutrient cycling, hydrology, plant growth, and provision of habitat. Snags provide habitat for cavity nesting animals such as woodpeckers, squirrels, and owls. Fallen logs protect seedlings from certain fungus in the soil, which cannot live on deadwood.[39] In the northern hardwoods of New England, one-third to one-half of native amphibians and mammals rely on logs at some stage in their life.[40] Biodiversity increases with the size of deadwood, because of the length of the decay process and the large number and types of habitats it provides. Many species of insects, small mammals, and birds can be found foraging and living among coarse woody debris in Chesapeake forests.

Photo: Clint Farlinger

Riparian Forests

Riparian forests—those that border streams, lakes, and estuaries—support numerous plants and wildlife because they connect aquatic and terrestrial ecosystems. Riparian areas in the eastern United States are among the most productive biological systems in the world.[41]

The Riparian Food Chain

Tree material (such as leaf litter, fruit, and large wood) from the forest canopy provides the foundation of the freshwater aquatic food web. In the east, small headwater streams receive between 60 and 99% of their food base from the surrounding forest.[43] As water passes through the forest on its way to a stream, it picks up an enormous variety of useful organic molecules. When that water enters a stream, a special blend of dissolved organic matter is dispersed like tea from a tea bag. Bacteria and algae consume this "watershed tea" as well as detritus from leaves and twigs, utilizing their stored energy for growth. Aquatic insects feeding on these microscopic organisms are consumed by fish and so on along the food chain. Aquatic life native to this region evolved to utilize this unique mix of organic materials derived from trees. Without food from trees, many stream species simply cannot survive.

Maintaining Aquatic Habitat

Many species of fish need consistent streamflow to live and breed. For example, the endangered American shad, a Chesapeake icon, requires from one to three cubic feet of water per second. Forests can moderate streamflow by slowing water from rain events and maintaining ground water flows.

Streamside forests shade the water and maintain cooler water temperatures in the summer, especially on small streams. The leafy tree canopy also helps to moderate dramatic fluctuations in water temperature, further reducing stress on fish. As water temperature increases, streams have less ability to hold oxygen and undergo important ecological reactions. Agricultural or grass-lined streams average 10 degrees Fahrenheit warmer than a forested stream and are often unable to support the growth of diatoms, beneficial algae and aquatic insects and the fish that depend on them. A few degrees can have a major effect on water quality and the survival of aquatic organisms.

Most aquatic organisms in streams live on the streambed. Forested streams produce nearly double the effective stream bottom habitat of their non-forested counterparts. Therefore, a network of tree roots and gravel/cobble bottom can increase the overall habitat of a forested stream reach more than a thousand times when compared to the bare soil bottom in a grass-buffered stream. Branches and tree trunks add habitat components and help shape the physical character of the stream. This large woody debris plays an important role in creating habitat that is favorable for fish. Studies have shown that forested streams have more than six times the amount of large woody debris than grass buffered streams, even though the grass segments were immediately downstream of forested reaches.[44]

A Globally Significant Diversity of Salamanders

The Appalachian Mountain forests, especially their southern extreme, are home to the most diverse salamander fauna in the world. With 168 species of salamanders, the United States ranks first internationally, followed by Mexico with 127 species. As a group, United States salamanders are threatened by habitat loss and degradation caused by land disturbance, loss of riparian areas and wetlands, development of habitat, logging, atmospheric pollution, and reduced water quality from agricultural, industrial, and residential runoff. Due to the broad ranges of some of these salamanders and their frequent occurrence in remote mountains, relatively few Appalachian species are threatened with extinction.[42]

Photo: Evan H.C. Grant

Forested riparian areas also improve aquatic habitat by reducing the amount of sediment and nutrients reaching streams. High levels of suspended sediment can abrade and clog gill tissues as well as bury fish eggs and habitat.[45]

Special Aquatic Habitats Under Pressure

Riparian Hemlock Forests

Eastern hemlock forests provide year-round habitat and are especially important to aquatic biodiversity. Their loss from Chesapeake forests, caused by the non-native hemlock wooly adelgid and the harvesting practice of high grading, could have significant ramifications. Streams flowing through hemlock forests can have higher invertebrate species richness and diversity than streams flowing through hardwood forests. The prized game fish, brook trout, is three times more likely to occur in hemlock streams than hardwood streams because of cooler stream temperatures in summer and warmer temperatures in winter.[46]

Forested Coldwater Streams

A loss of shade, habitat, bank-and-pool structure, and food production has led to a 30 to 50% loss of coldwater streams.[47] A recent sample of coldwater streams in Maryland revealed that 34% were severely degraded. The loss of this habitat has led to drastic declines in aquatic species like the brook trout.

Until the 19th and 20th centuries, brook trout populations thrived in the clean, clear, and cold streams that flowed through heavily forested regions throughout a large portion of the Bay watershed. However, much of the supporting habitat was destroyed at the turn of the 19th century by logging and agricultural practices. Agriculture and development continue to degrade riparian habitat today.

States in the Bay watershed have seen brook trout eliminated from nearly a third of subwatersheds in the species' historic range. Where populations still occur, supporting habitat in 65% of the streams is diminished and only 6% are in fully functioning condition.[48] Reproducing populations of brook trout are likely to disappear from subwatersheds when the percentage of human land uses like residential subdivisions is greater than 18%. Brook trout in Maryland are not present in streams where watersheds have more than 2% impervious cover.[49]

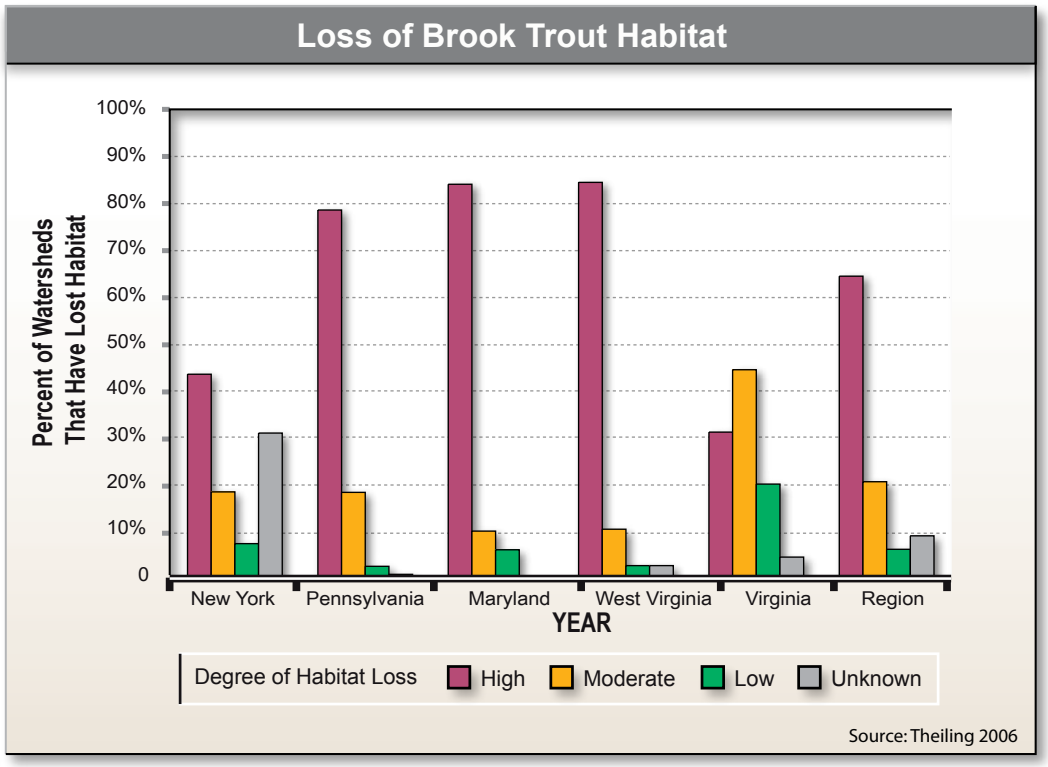


Photo: Ted Weber

Key Factors of Habitat Change

Overabundant Deer Populations

The white-tailed deer is a key threat to overall forest habitat quality in the Chesapeake Bay watershed. In many portions of the region, land use change and lack of management over the past 80 years have created forests where vegetation composition and structure are regulated by browsing patterns of white-tailed deer.[50] Increasing deer populations are also a public safety concern. Deer collisions with vehicles have increased greatly, and deer infested with Lyme disease-carrying ticks are abundant in forest fragments.[51]

Currently, hunting is the only viable option to control deer populations. The use of hunting is limited in rapidly growing suburban areas because of public safety concerns and the perception of inhumane treatment. Access for hunters is more restricted than ever because the greater number of private families owning Chesapeake forestland. Additionally, current hunting techniques are not always the most effective for controlling deer populations. Hunters tend to visit similar locations and rarely travel more than a third of a mile away from a road.[52]

Before European settlement, deer populations were probably as low as two deer per square mile over large sections of the mature deciduous forest.[53] Historic populations were limited by large predators like the gray wolf and from hunting by Native Americans. However, the abundance and nutritional value of food likely was the most important influence on population size for most deer herds. The white-tailed deer population severely declined throughout the eastern United States over the next 300 years, reaching an historic low by 1900 mostly from over-hunting in areas where deer remained a staple of the frontier diet. In Virginia, deer were effectively extirpated from most of the state except for a few sizable herds in northern Virginia and areas where hunting was minimal.

Deer numbers have since grown tremendously throughout the Bay watershed. In the Chesapeake region of Pennsylvania, deer density increased 80% between 1999 and 2003.[54] In Virginia, 30% of Chesapeake counties supported high densities of deer from 1994 to 2003.[55] While deer were historically a forest species, they are currently most abundant at the nexus of farmland (food source), forestland (protective cover), and areas with a high enough human population to preclude hunting. Female fawns are more likely to reproduce in farmland than in forestland because of the stability of food sources in agricultural areas.[56] Deer have also benefited from game management and forestry practices that promote preferred food sources such as shrubland and early succession forests.

Important Tree Species with Low Regeneration Rates in Pennsylvania

Black cherry
Oak
Sugar maple
Red maple
White pine
Eastern hemlock
Hickory
Yellow-Poplar
Ash
Black birch
Beech
Conifer
Basswood
Cucumbertree
Walnut
Butternut

Source: McWillliams 2005

Decimation of American Ginseng

The wild herb, ginseng, is an important economic and cultural forest plant in the eastern United States. Overabundant deer populations and illegal harvesting threaten ginseng across its range in the Chesapeake Bay watershed. Current ginseng populations must have at least 800 plants to have a 95% chance of surviving into the next century and sustaining the herb's value to Appalachian communities. However, over-browsing by white-tailed deer has limited the average population size to 93 plants in the Appalachian region. To ensure the long-term viability of ginseng populations, deer browsing levels would need to drop by 50% or more.[57]

Photo: USDA Agroforestry Center

Rising Populations of Invasive Species

Pests

Without effective restrictions or preventative measures, non-native and invasive forest pests and diseases will continue to dramatically alter forest conditions in the Bay watershed. Once non-native pests establish themselves, it is nearly impossible to remove them because they reproduce rapidly, disperse easily, and lack natural predators. This means that preventing the entry of new pests and rapidly attacking new outbreaks is paramount.

Some pests and diseases, such as chestnut blight, Dutch elm disease, beech bark disease, and gypsy moth have had long-term, devastating impacts on forest ecosystems. There are currently 12 major pests or associated diseases that are having widespread and serious effects.[58] These include:

- Gypsy moth - Despite the discovery of a pathogen that has reduced gypsy moth populations, the moth's range is expected to spread across the Bay watershed.[22,59] After repetitive years of defoliation, high densities of gypsy moth weaken and kill trees. The gypsy moth was first introduced in the United States to start a silk industry in 1869; since then, the moth has fed on the foliage of hundreds of tree species, especially oaks.[60]

- Hemlock woolly adelgid - Within decades, the Asian hemlock wooly adelgid is expected to eliminate most of the eastern hemlock forest ecosystem remaining in the Chesapeake region. Chemical insecticides, biological controls, and even harsh weather have proved ineffective in slowing the spread of the adelgid over the past half-century. Mixed hardwood species tend to grow in the openings created by the demise of hemlock groves, but this new forest does not support the same plant and wildlife communities as the deposed eastern hemlock.[61]

- Beech bark disease - There are currently no practical tools to prevent widespread defects and mortality in forests infected by the beech bark scale that causes the disease.[62] Over the past two decades, the number of American beech trees has declined by 11% in the northern Bay watershed.[5] As beech bark disease spreads, small mammal and other forest wildlife populations will continue to be affected by the loss of the once abundant and nutritious beechnut crop that is only produced by mature trees.[63]

- Southern pine beetle - The southern pine beetle has become a significant pest in the southern portion of the Bay watershed because of the intentional suppression of natural fire. Fire suppression and lack of thinning has created dense stands of loblolly pine trees in various stages of health—ideal conditions for the southern pine beetle. This beetle is native to the southern portion of the Bay watershed, but changes in the natural fire regime have limited the resilience of Chesapeake forests to the southern pine beetle.

The following pests have been discovered recently and underscore the constant and significant threat to Chesapeake forests:

- Emerald ash borer - White and green ashes are dominant trees in the Chesapeake's forests and a primary component of riparian forest buffers. There are over 470 million ash trees in the Bay watershed. Elm, walnut, and other trees in the Bay watershed are also susceptible to mortality because of the emerald ash borer.

- Sudden oak death - Though not currently known to affect eastern forests, sudden oak death is expected to spread to this area in the future. Since the mid-1990s, the fungus-like organism has caused substantial mortality in numerous oak species and other plants. Sudden oak death has been found in 18 states since 2000, including Maryland.[64]

- Asian longhorned beetle - This beetle will threaten many Chesapeake hardwood species including maple, birch, poplar, and sycamore. Approximately 70% of the trees in Pennsylvania and more than 50% in West Virginia are at risk to infestation.[65] Quarantines of infestations in New York, Chicago, and New Jersey are attempting to prevent the export of wood, tree debris, and nursery products that could be infected with the beetle.[66]

Major Insects and Diseases in the Chesapeake Bay Watershed

Nativity	Insect or Disease	Primary Tree Host(s)	Affects: Low	Affects: Med	Affects: High
Exotic	Hemlock woolly adelgid	*Eastern hemlock*			↑
	Beech bark disease	*American beech*			↑
	Gypsy moth	*All oak and basswood*			~
	Chestnut Blight	*American chestnut*			–
	Dutch elm disease	*American elm*		⇓	
Native	Southern pine beetle	*Loblolly and Virginia pine*			↑
	Anthracnose	*American sycamore, ash and beech*		~	
	Looper complex/fall cankerworm	*Maple and oak*		~	
	Locust leaf miner	*Black locust*		~	
	Variable oak leaf caterpillar	*Oak and beech*	~		
Unknown	Dogwood anthracnose	*Flowering dogwood*			↑
	Oak wilt	*Red oak*			⇑

↑ Increasing ~ Variable – Static ⇓ Static to Decreasing ⇑ Static to Increasing

Source: USDA Forest Service / FHM 2005, Asaro 2005, Yockey 2005

Plants

Invasive trees, shrubs, vines, and grasses have become so common that some are now permanent components of many Chesapeake forest ecosystems. Invasive plants, often non-native, grow and reproduce rapidly, killing and out-competing native species in the process.

Climate causing change is causing vines to grow faster than their tree hosts. They lower the quality of food sources and shelter for wildlife, eliminate host plants of native insects, and compete with native plants for pollinators.

The most successful invasive plants lack natural herbivores, spread underground, produce large numbers of durable seeds, and disperse seeds in multiple ways. Some invasives also produce chemicals that kill nearby native vegetation to create their own space to grow. They are often very attractive plants, which leads to intentional plantings by amateur and professional gardeners. In addition, the disturbed habitats that invasives thrive in continue to spread with human activity.

While only 5% of all plants in the eastern United States are non-native and invasive, and only a small portion invade forests,[67] some of these plants can cause significant problems. Particularly invasive plants that have made Chesapeake forests their home include:

- Tree of heaven (Ailanthus) - This tree grows rapidly in a variety of conditions and, consequently, is able to form dense stands that displace native plants by blocking sunlight and capturing available nutrients and water. The tree of heaven also produces chemicals that kill or prevent other plants from growing nearby.

- Japanese barberry - The bright red, oblong berries of this shrub have become a familiar sight in Chesapeake forests, where large clusters of the plant out-compete native vegetation. Birds and wildlife quickly spread the attractive and edible seeds.

- Oriental bittersweet - This vine kills other plants by blocking light, girdling plant tissues, and covering then even toppling trees with its immense weight.

- Japanese stilt grass - This grass covers extensive areas and replaces native species, including those that occur in forest interiors.[68]

Major Invasive Plants

Trees

Norway maple* (*Acer platanoides* L.)
Siberian elm* (*Ulmus pumila* L.)
Tree of heaven (*Ailanthus altissima*)
Princess tree (*Paulownia tomentosa* Thunb.)

Vines

Oriental bittersweet* (*Celastrus orbiculatus* Thunb.)
Japanese honeysuckle* (*Lonicera japonica* Thunb.)
Mile-a-minute* (*Polygonum perfoliatum* L.)
English ivy* (*Hedera helix* L.)
Kudzu (*Pueraria montana var. lobata* Willd.)
Exotic wisterias (*Wisteria floribunda* (Willd.) DC. , *W. sinensis* (Sims) DC.)
Periwinkle (*Vinca major* L. , *V. minor* L.)
Japanese hops (*Humulus japonicus* Sieb. & Zucc.)

Shrubs

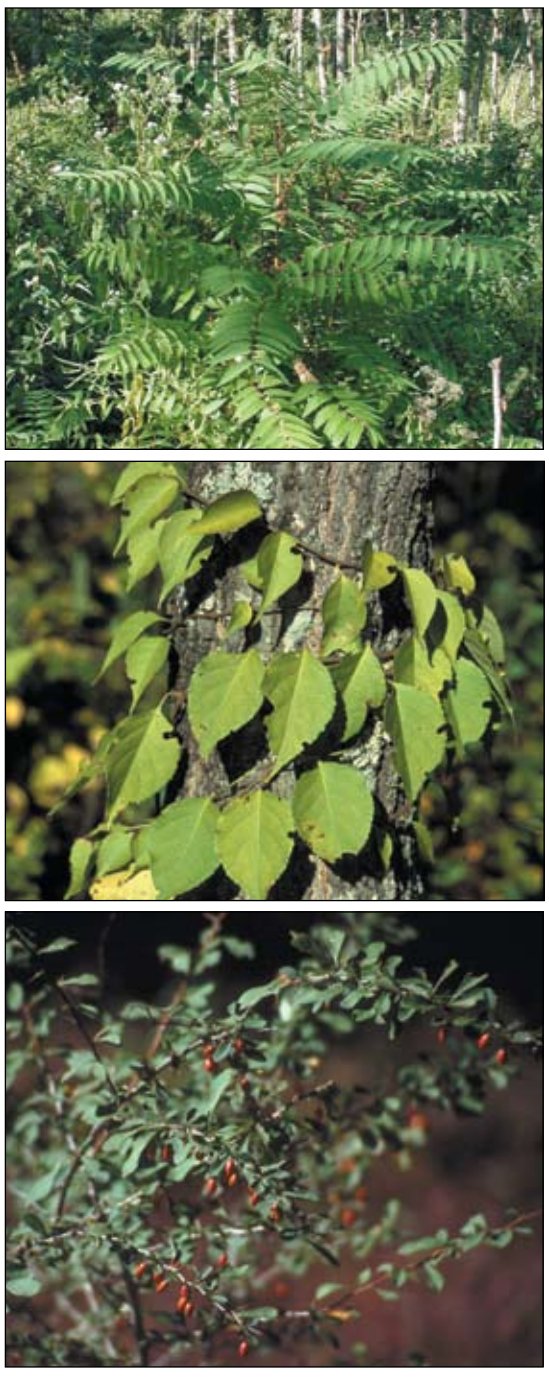
Japanese barberry* (*Berberis thunbergii* DC.)
Chinese privet* (*Ligustrum sinense* Lour.)
Multiflora rose* (*Rosa multiflora* Thunb.)
Winged euonymus* (*Euonymus alta*)
Exotic bush honeysuckles (*Lonicera* spp.)
Wineberry (*Rubus phoenicolasius* Maxim.)
Common reed (*Phragmites australis* Cav.)
Autumn olive (*Elaeagnus umbellata* Thunb.)
Japanese spiraea (*Spiraea humalda* Burven)

Grasses and Herbs

Japanese stiltgrass* (*Microstegium vimineum* (Trin.) Camus)
Reed canary grass* (*Phalaris arundinacea* L.)
Chinese silver grass (*Miscanthus sinensis* Anderss.)
Johnson grass (*Sorghum halepense* (L.) Pers.)
Garlic mustard* (*Alliaria petiolata* (Bieb.) Cavara & Grande)
Japanese knotweed* (*Polygonum cuspidatum* Sieb. & Zucc.)
Dame's Rocket (*Hesperis matronalis*)
Purple loosestrife (*Lythrum salicaria* L.)
Pale yellow iris (*Iris pseudacorus* L.)
Canada thistle (*Cirsium arvense* (L.) Scop.)
Exotic Bamboos (*Bambusa, Phyllstachys* and *Pseudosasa* spp.)

* Invades forest interiors

SOURCE: Chesapeake Bay Program 2005



Photos: Chris Evans UGA

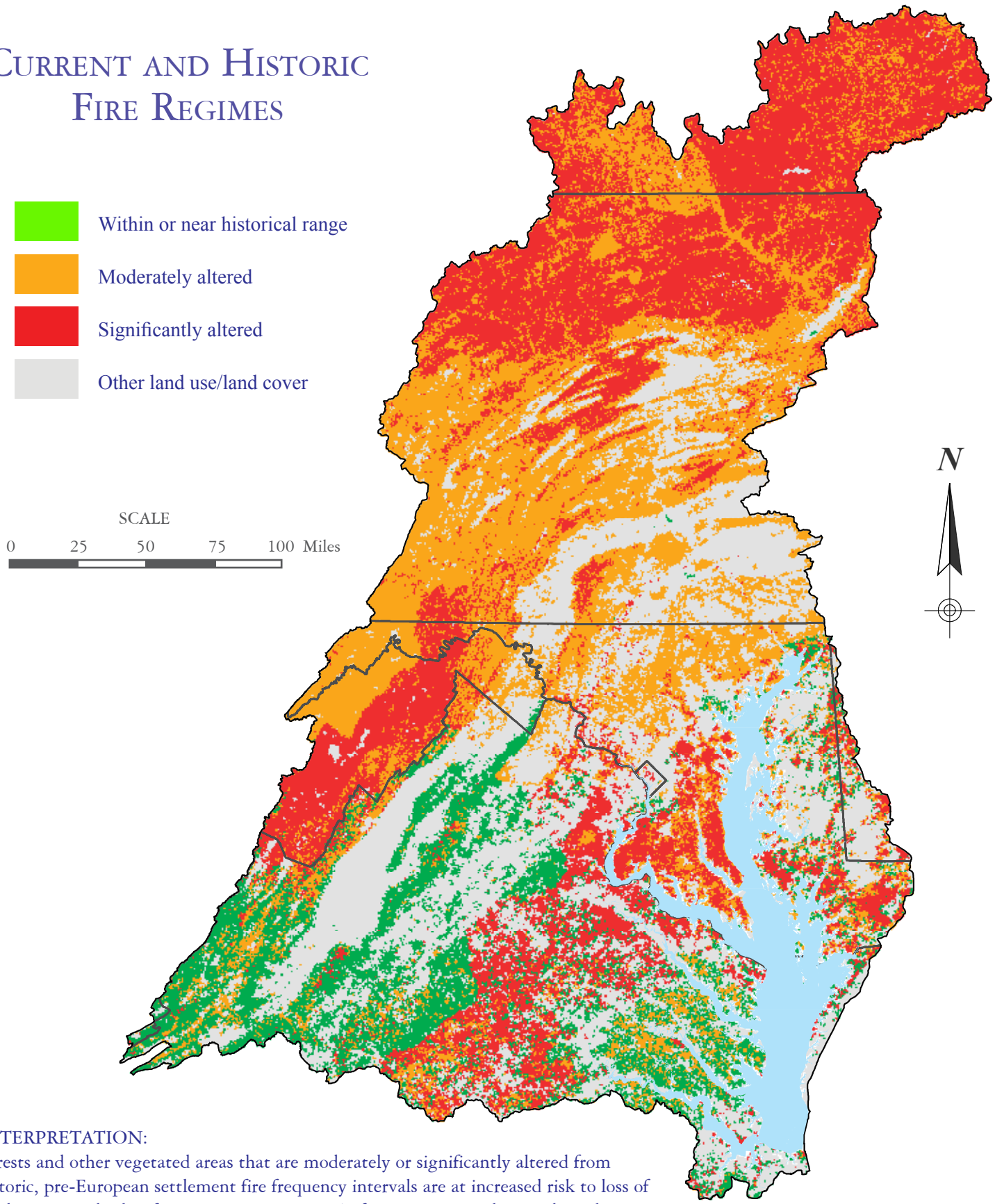
top to bottom: Tree of heaven, Oriental bittersweet and Japanese barberry.

Effects of Suppressing Fire

More than 80% of Chesapeake forests have seen changes in condition, species diversity, and increased risk to catastrophic wildfires because of the suppression of natural, low-intensity fires.[69] Fire is important to forest ecosystems for several reasons. It promotes mineral cycling, creates habitat for many animal species, and exposes the mineral soil for seed germination. However, in the early 1900s, widespread and destructive high-intensity wildfires created by poor land management led to the establishment of fire control as one of the dominant forest management practices of the 20th century.

Over the past century, species whose numbers were traditionally controlled by fire—like red maple, tulip poplar, sugar maple, and American beech—have increased, while slow growing, fire resistant species like white and red oak and pine have decreased.[7] The prolonged absence of natural fire has also allowed the density of trees and shrubs to increase substantially, which further increases the likelihood of severe wildfires. Road access and rapid detection and suppression capabilities have made large wildfires a less serious problem for Chesapeake forests. However, expanding rural and suburban development has introduced new ignition sources and created increased risk for some local forests and residents.[70,71] When they occur, high-intensity wildfires can have serious impacts on local forests and communities.

Current and Historic Fire Regimes



INTERPRETATION:
Forests and other vegetated areas that are moderately or significantly altered from historic, pre-European settlement fire frequency intervals are at increased risk to loss of biodiversity and other forest components. 83% of vegetation is either moderately or significantly altered and covers the majority of the Bay watershed.

SOURCE: Schmidt et al. 2002

Forest Communities that Depend on Fire

Several types of pine forest, open woodlands on serpentine bedrock, and assorted dry forests of Appalachian ridges all depend on fire to maintain their integrity. Often, fire-created openings are soon filled with abundant grasses and wildflowers that arise from decades-old underground seeds. They flourish briefly, producing new seeds that lie dormant until the next fire. Meanwhile, new tree shoots arise from seed or, more often, from undamaged underground parts of the original trees. As the new trees grow, they shade out the sun-loving plants, and a new forest cycle begins. If fire is suppressed, fire-intolerant trees eventually dominate the land, shrubs grow tall, and dead wood accumulates, conditions that can increase the intensity of future fires.

Photo: Sandra Y. Erdle © VA DCR Natural Heritage

Perscribed Fire to Restore Pine/Scrub Oak Forest in Virginia Coastal Plain

Some of the rarest plants in the Chesapeake region grow in areas of recurrent fire. The serpentine barrens, on peculiar bedrock of the Piedmont (especially between Baltimore and Philadelphia), have abundant stands of unusual species. Examples include the blackjack oak; various grasses characteristic of Midwestern prairies; a fern more common in Canada; the sandplain gerardia, a rare wildflower; and the serpentine chickweed and Reed's moss—plants that occur nowhere else on Earth.

In the sandstone ridgetops of the Appalachians, fire maintains sandy openings in pine forests. These openings generate an assemblage of strange plants. Some, such as the turkey-beard and the sand-heather, are characteristic of coastal habitats, while others, such as the silvery nailwort, are characteristic of Appalachian mountaintops. One of these wildflowers, the white-flowered alumroot, grows in only a few dozen locations worldwide—most of which are on a few mountain ridges in the Potomac River headwaters of the Chesapeake Bay watershed.[72]

Indicators for Sustainable Chesapeake Forests

To ensure the rich diversity of Chesapeake forests is present for future generations, the following indicators can be used to track biological conditions over time:

- Area of forest types
- Forest size class and age group
- Area of forestland affected by insects, diseases, plants, and deer

Chapter in Perspective

Healthy forests are in a continual state of flux. However, Chesapeake forests are having difficulty adapting to a new suite and frequency of forces of change such as rapid land use change, expanding deer populations, and rising numbers of invasive plants and pests. These forces have influenced the biological and physical condition of forests, altering the natural diversity of plant and animal life and decreasing the structural complexity. As these forces degrade forest health, the total ecological value of Chesapeake forests is also diminished. Acre for acre, forestland is the most beneficial land use for protecting water quality, and every loss of forestland contributes to the impairment of the Chesapeake Bay. This connection is explored in the next chapter, Forests: The Key to Watershed Function.